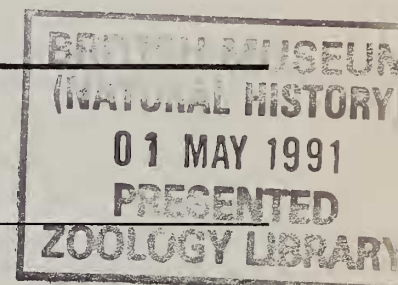


Tinogullmia riemanni sp. nov. (Allogromiina; Foraminiferida), a new species associated with organic detritus in the deep-sea

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CONTENTS

Introduction	93
Materials and methods	93
Systematic descriptions	93
Ecology	97
References	98

INTRODUCTION

Recent studies, carried out in the northeast Atlantic as part of the benthic biology programme at the Institute of Oceanographic Sciences Deacon Laboratory (IOSDL), have shown that benthic foraminifera, together with nematodes, are the dominant organisms in the meiofaunal (42–1000µm) size range (Gooday 1986b, 1988a, Gooday & Lamshead 1989). The foraminiferal populations are highly diverse and include many new taxa, among them members of the Allogromiina (Gooday 1986b). This suborder includes foraminifera with morphologically simple tests composed of proteinaceous material which is often flexible and transparent (Loeblich & Tappan 1988). Because they have delicate tests and are easily overlooked or destroyed during the processing and sorting of samples, allogromiins are the least well-known of the main foraminiferal suborders. In particular, few species have been reported from the deep-sea (Gooday 1986a).

The purpose of this paper is to describe a new allogromiin which is abundant in samples from the abyssal and bathyal northeast Atlantic. The new species is of special interest because of its association with organic detritus.

MATERIALS AND METHODS

The material described was collected with a multiple corer (Barnett *et al.*, 1984) at two localities. The bathyal site (51° 36'N, 13° 00'W, 1350m) is located in the Porcupine Seabight, an embayment of the continental shelf to the southwest of Ireland. It was sampled during RRS *Challenger* cruise 10/82 (Stn 51615, 22–23 July 1982). The abyssal site (4500m) was sampled during the third cruise of the German research vessel FS *Meteor* (Stns 172, 179, 200; 7–14 August 1986). It is located in the BIOTRANS box (47° 00'–47° 30'N, 19° 00'–20° 00'W), an area which has been subject to an

intensive investigation by the Institut für Hydrobiologie und Fischereiwissenschaft, Universität Hamburg.

Nine sediment subsamples (identified as 1A, 1B etc; see Gooday & Lamshead 1989) from the cores collected at Stn 51615 were washed through a series of sieves and the resulting residues stained with rose Bengal and sorted wet under a binocular microscope. In the case of the BIOTRANS samples, aggregates of organic detritus, which provide a microhabitat for the new species, were lifted from the core surfaces using forceps. Later, in the laboratory, they were gently teased apart in a cavity block or cavity slide to release the inhabiting organisms. Allogromiin foraminifers extracted from these samples were mounted in anhydrous glycerine on a glass slide under a supported cover slip sealed with D.P.X. For further details of sampling and processing methods see Gooday (1986a, 1986b, 1988a, 1988b, Gooday & Lamshead 1989).

Drawings were made using a Wild M20 drawing tube. Photographs were taken on an Olympus BH2 photomicroscope and the results recorded on Ilford FP4 film.

SYSTEMATIC DESCRIPTIONS

Suborder ALLOGROMIINA Loeblich & Tappan, 1961
 Family ALLOGROMIIDAE Rhumbler, 1904
 Subfamily SHEPHEARDELLINAE Loeblich & Tappan, 1984

Genus TINOGULLMIA Nyholm, 1954
Tinogullmia riemanni sp. nov.

1988a Allogromiid sp. Gooday: p. 72, Fig. 1a, 1b.

DIAGNOSIS. Small species of *Tinogullmia* (<300µm long) with elongate, lenticular, usually asymmetrical test, tapering at both ends. Apertures located at extremities of short necks which extend out from ends of test. Wall delicate, transparent, proteinaceous. Protoplasm fairly homogenous and free from obvious detrital particles; usually with single large nucleus.

NAME. In honour of Dr Franz Riemann who was the first to observe this species in phytodetritus aggregates on board the *Meteor*.

MATERIAL. 81 specimens from *Meteor* Stn 172 (47° 25.35'N, 19° 39.46', 4438m depth); 102 specimens from *Meteor* Stn 179 (47° 24.95'N, 19° 48.00'W, 4538m depth); 102 specimens from *Meteor* Stn 200 (47° 24.16'N, 19° 45.65'W, 4520m); 171 specimens from *Challenger* Stn 51615 (51° 35.1'–51° 36.0'N, 12° 59.3'–13° 00.6'W, 1345–1361m). The *Challenger* material is in the author's collection at IOSDL.

HOLOTYPE. The holotype and 37 paratypes, from phytodetritus collected at *Meteor* Stn 179 (core 1), are deposited in the Natur-Museum Senckenberg, Frankfurt am Main, under reg. no. SMF 1086 (one slide). Twenty-one additional paratypes are deposited in the British Museum (Natural History), London under reg. nos ZF4783–4793 and ZF4794–4803 (two slides).

DESCRIPTION. (*Meteor* material; Figs 1a–xx, 2a–s; 3a–l; 8a, b, e). Test dimensions are summarised in Table 1 and test length is plotted against height in Fig. 4. The test is elongate, approximately circular in cross-section, with apertures located at the ends of short tubes which extend out from either end of the test. The tubes are 2.7–13.3µm long (usually 4.0–10.7µm, mean $5.8 \pm 2.1\mu\text{m}$, 172 observations) and 4.0–10.7µm wide (mean $6.0 \pm 7.0\mu\text{m}$, 77 observations). In principle, most specimens are lenticular in lateral outline and taper towards the apertural tubes. The outline is usually (>80% of specimens) asymmetrical with one side forming a convex arc and the other side ranging from gently convex to gently concave. The maximum height is generally situated near the midpoint of the test but sometimes lies slightly nearer one end. In most cases, the apertural tubes are located below a line drawn through the mid-point of the test and usually are directed at a slight angle to the long axis. Occasional elongate specimens are sausage or banana-shaped. Others have more or less symmetrically oval to lenticular outlines with the tubes originating from near the mid-line. This apparent symmetry may arise, however, because the test is being viewed from above or below rather

than from the side. In a few such specimens (about 3% of the total) the outline is a broad, symmetrical oval (length:height ratio 1.85–2.50).

The protoplasm is colourless and fairly homogenous with no obvious exotic inclusions. It occupies most of the test interior. At either end of the test the protoplasm is usually interrupted by tubular invaginations which appear to be extensions of the lumens of the apertural tubes into the protoplasm. These structures are probably some form of endosolon (*sensu* Knight 1986). A fine thread of protoplasm sometimes extends along the axis of the endosolon into the apertural tube. In 9.5% of specimens, the protoplasm is divided into two (in one case three) sections by a more or less obvious constriction which is also reflected in the test wall. There is usually (about 90% of specimens) a single, large, centrally located nucleus, 8–32µm in diameter (usually 10–19µm, mean $16 \pm 4\mu\text{m}$, 202 observations). A few specimens (about 3%) appear to be multinucleate, their protoplasm containing up to 11 or 12 smaller (4–5µm), nucleus-like bodies rather than a single large nucleus.

DESCRIPTION. (*Challenger* material; Figs 5a–ff, 6a–jj, 7a–m, 8c, d, f, g). Specimens from the bathyal Porcupine Seabight tend to be larger, on average, than those from the abyssal BIOTRANS area (Table 1). Two rather distinct forms can be recognised in this material. In form A the apertural tubes are weakly developed, usually forming only slight extensions (3–10µm long) at either end of the test. The shape of the test is broadly similar to that of the BIOTRANS specimens. It is elongate, tapers towards both ends, and usually has an approximately lenticular lateral outline with one side being convex and the other straighter and sometimes slightly concave. Overall, the test is often gently curved. The apertures are located to one side of the mid-line. However, in a few cases, the test is more symmetrical in outline with the line joining the apertures passing close to the mid-point.

In form B, the apertural tubes are clearly developed structures, 8–27µm long (mean $18.0 \pm 4.3\mu\text{m}$, $n = 66$) and 5–19µm wide (mean 9.9 ± 3.5 , $n = 64$). The lateral outline resembles that of form A, although it tends to be more oval and symmetrical, with the tubes located closer to

Table 1 *Tinogullmia riemanni*; dimensions of specimens from *Meteor* and *Challenger* samples

	Range (µm)	Mean ± S.D. (µm)	Number of measurements
<i>Meteor</i> material:			
Length including tubes (L1)	44–248	114.4 ± 35.0	268
Length excluding tubes (L2)	39–235	106.7 ± 33.9	261
Width (W)	13–96	35.6 ± 12.2	271
L2 : W ratio	1.85–4.81	3.03 ± 0.49	260
<i>Challenger</i> material (Form A):			
Length including tubes (L1)	110–285	181.2 ± 39.1	73
Length excluding tubes (L2)	116–282	173.5 ± 40.7	29
Width (W)	25–101	57.6 ± 12.7	73
L2 : W ratio	1.83–4.37	3.14 ± 0.56	45
<i>Challenger</i> material (Form B):			
Length including tubes (L1)	98–318	173.0 ± 47.6	37
Length excluding tubes (L2)	82–294	140.9 ± 43.4	38
Width (W)	34.4–93.0	55.0 ± 13.0	38
L2 : W ratio	1.87–3.21*	2.47 ± 0.37*	37

* excludes one elongate specimen with L2 : W ratio = 5.3

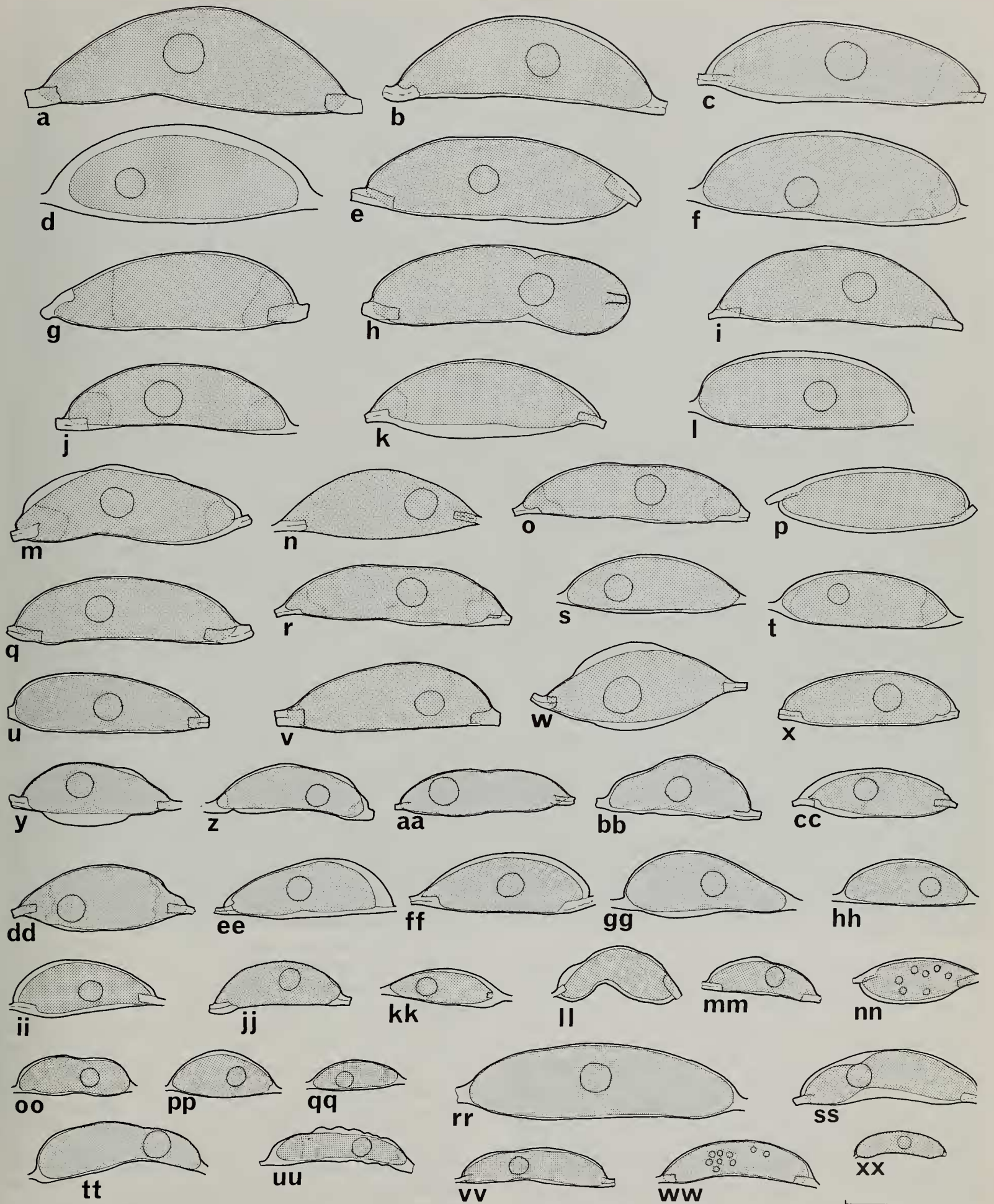


Fig. 1 *Tinogullmia riemanni* sp. nov. Specimens from BIOTRANS phytodetritus samples. Holotype (a). Other specimens are from Stns 172 (s, hh, oo, pp, rr, ww, xx); 179 (a–e, g, h, m, o–r, u, w, x, z–bb, dd–gg, ii–jj, mm, nn, qq, tt, uu); 200 (j, l, n, t, v, y, cc, kk, ll, vv). Specimens from BIOTRANS sediment samples: Stn 179 (f, i, k, ss). The holotype is deposited under SMF 1086. Other specimens are deposited under SMF 1086 (c, e, u, w, jj); ZF4783–4786 (h, m, o, r); ZF4794–4795 (k, ss). The remaining specimens are unregistered. Scale bar = 100µm.

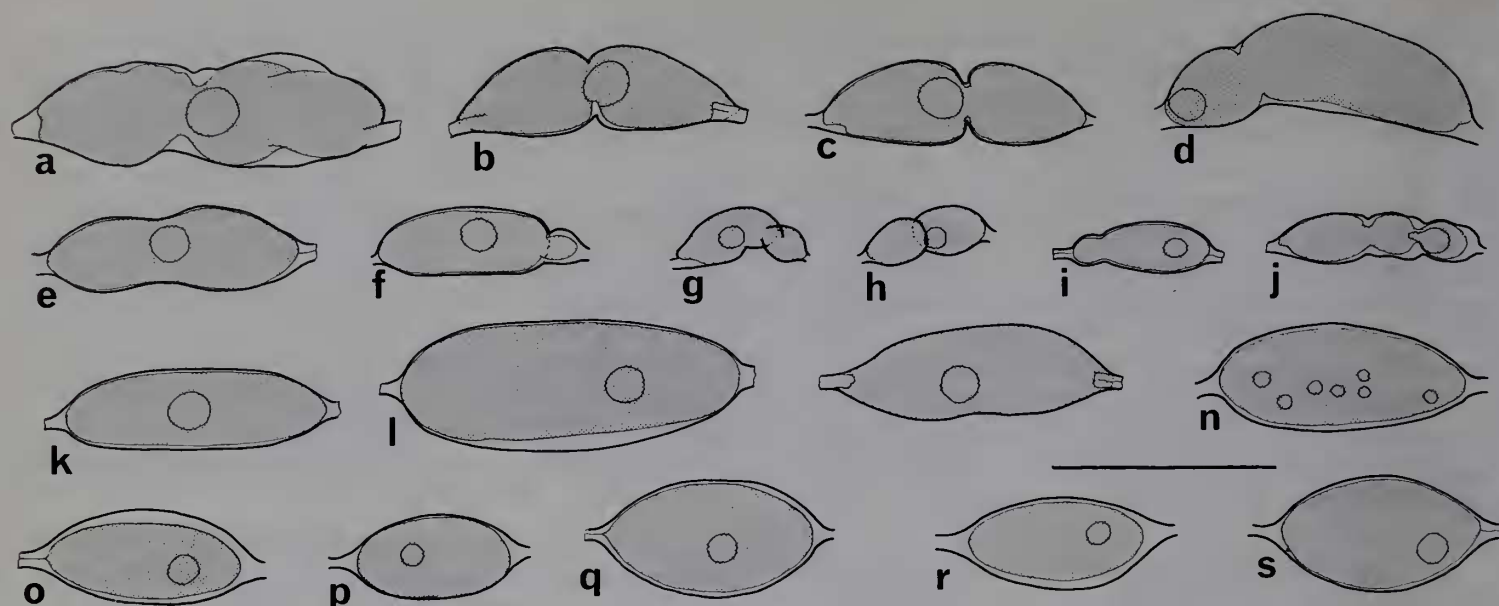


Fig. 2 *Tinogullmia riemanni* sp. nov. Specimens from BIOTRANS phytodetritus samples: Stn 172 (c, f, n); 179 (b, e, g, i, k, l, s); 200 (a, d, h, j, l). Specimens from BIOTRANS sediment samples: Stn 179 (o-r). Specimens are deposited under SMF 1086 (b); ZF4796-4799 (o, p, q, r). The remaining specimens are unregistered. Scale bar = 100µm.

the midline. The tubes themselves are often directed at a slight angle to the mid-line. One usually elongate specimen (length:width ratio = 5.3) has an almost cylindrical test (Fig. 6i).

In both forms, the larger and more regular shaped specimens have approximately circular cross-sections or are slightly flattened. Smaller specimens may be more clearly flattened and the degree of flattening sometimes varies along the length of the specimen. Overall, the thickness of the test ranges from 60% to 100% of the width.

An endosolon is sometimes developed in both forms. As in the BIOTRANS material, the protoplasm may be divided into two or three sections by constrictions which are also reflected in the test wall. The thickness of the protoplasm may vary also, with some areas being thicker than others. In form B, the protoplasm is separated from the test wall by a distinct space of narrow but uniform width. Also, a fine thread of protoplasm extends along the axis of the tube. About 90% of specimens have a single nucleus 10–26µm in diameter (mean 17.4 ± 3.3). Some of the remaining specimens have a number of smaller nuclei.

REMARKS. The two forms in the Porcupine Seabight material differ from each other mainly in the degree of development of the apertural tubes. Compared with specimens from the type locality, both forms are somewhat larger and sometimes slightly flattened rather than circular in cross section. The apertural tubes are also more strongly developed in form B than in the BIOTRANS specimens. These differences are relatively minor, particularly considering the notorious morphological variability of allogromiins (Arnold 1954, Grell 1988, Hedley *et al.*, 1968, Schwab 1977, Siddal 1880). There is little doubt that the Porcupine Seabight specimens, and those from the type locality, together constitute a single species.

The elongate test with terminal apertures places this species clearly within the Shephardellinae, as defined by Loeblich & Tappan (1988, p. 15). This subfamily includes four genera: *Nemogullmia* Nyholm 1953, *Phainogullmia*

Nyholm 1955, *Shephardella* Siddal 1880, and *Tinogullmia* Nyholm 1954, all of which are extant. The new species most closely resembles *Tinogullmia* in general test morphology, the development of terminal apertural tubes, the presence of a single nucleus, and the relatively homogenous protoplasm free from detrital particles and other exotic inclusions. *Nemogullmia* and *Shephardella* are both much larger (1–19mm) and more elongate (often thread-like), while *Phainogullmia* has an opaque, yellowish-brown test wall composed of superimposed lamellae.

Tinogullmia hyalina Nyholm 1954, the type species of this hitherto monotypic genus, has not been reported since it was first described from 30–70m depth in the Gullmar Fjord, Sweden (Nyholm 1954). The apertural tubes of *T. hyalina* closely resemble those developed in *T. riemanni* form B from Stn 51615. However, *T. hyalina* differs from the new species in several respects. It is much larger (1.1–1.3mm), more elongate, tubular in shape, and sometimes has a large, centrally located vacuole. *Tinogullmia riemanni* usually lacks a vacuole, although a bubble-like cytoplasmic structure, resembling the central vacuole of *T. hyalina*, is clearly visible near one end of the protoplasmic mass in two specimens of *T. riemanni* from Stn 51615 (Fig. 8c).

The new species usually has a single, large, clearly visible nucleus. However, a number of smaller nuclei are present in a few specimens. In some species of primitive, monothalamous foraminifera, nuclear polymorphism is a feature of the life-cycle, the uninucleate specimens being gamonts (which reproduce sexually) and the multinucleate specimens being agamonts (which reproduce asexually) (Goldstein 1988). Some elongate allogromiins, for example *Nemogullmia longivariabilis* Nyholm 1953 and *Cylindrogullmia alba* Nyholm 1974, undergo 'serial budding' during which incipient new individuals are delimited by constrictions of the protoplasm and test. Rather similar test constrictions occur in some specimens of *T. riemanni*. However, constricted individuals never have more than one nucleus and therefore seem unlikely to be undergoing budding. Constrictions unrelated to reproduction have been observed in *Phainogullmia aurata* Nyholm 1955.

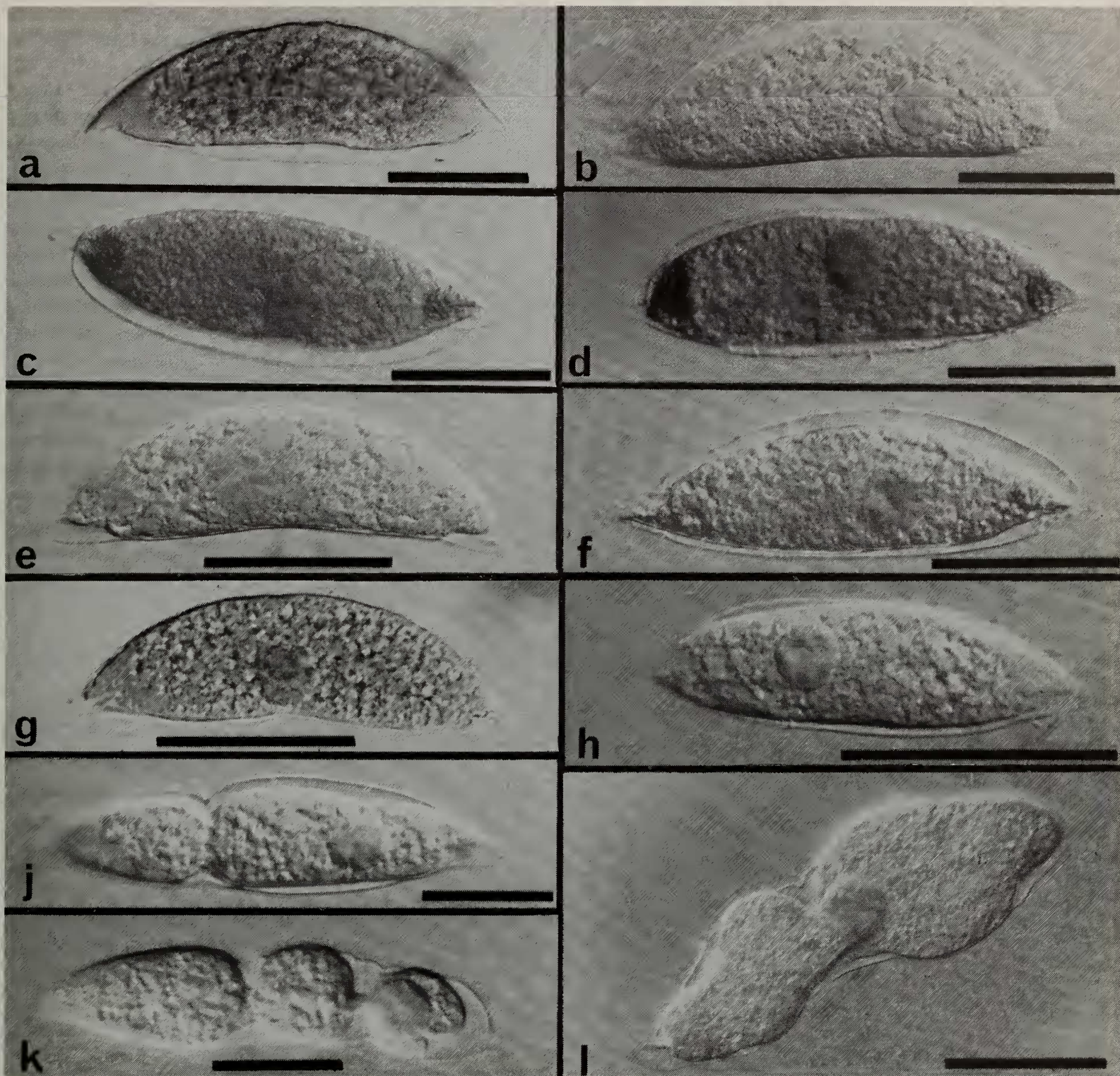


Fig. 3 *Tinogullmia riemanni* sp. nov. Specimens from BIOTRANS phytodetritus samples: Stns 179 (a, g); 200 (b, e, h, i, j, k). Specimens from BIOTRANS sediment samples: Stn 200 (c, d, f). Scale bars: a-h, k = 50µm; i, j = 25µm. All photographs taken using Nomarski interference contrast.

ECOLOGY

In the multiple corer samples collected in the BIOTRANS area, the sediment surface was sometimes overlain by brownish-green phytodetritus, either as a more or less complete layer, or as isolated aggregates (Gooday 1988a, Lochte & Turley 1988; Thiel *et al.*, in press). This material was first described from the Porcupine Seabight (Billett *et al.*, 1983, Lampitt 1985, Rice *et al.*, 1986). It consists of phytoplankton, and

other organic remains, bound together into gelatinous masses which settle rapidly (100–150m per day) to the sea-floor following the spring bloom. Most specimens (93.7%) of *Tinogullmia riemanni* from this site were found embedded in the phytodetritus and only a few (6.3%) occurred in the underlying sediment (Gooday 1988a). This was the most abundant species in the phytodetritus assemblages, making up 41.8% of all foraminiferal inhabitants, almost twice as many as the second ranked species *Alabaminella weddellensis* (Earland) (21.2%).

Multiple corer samples were collected during April (Stn

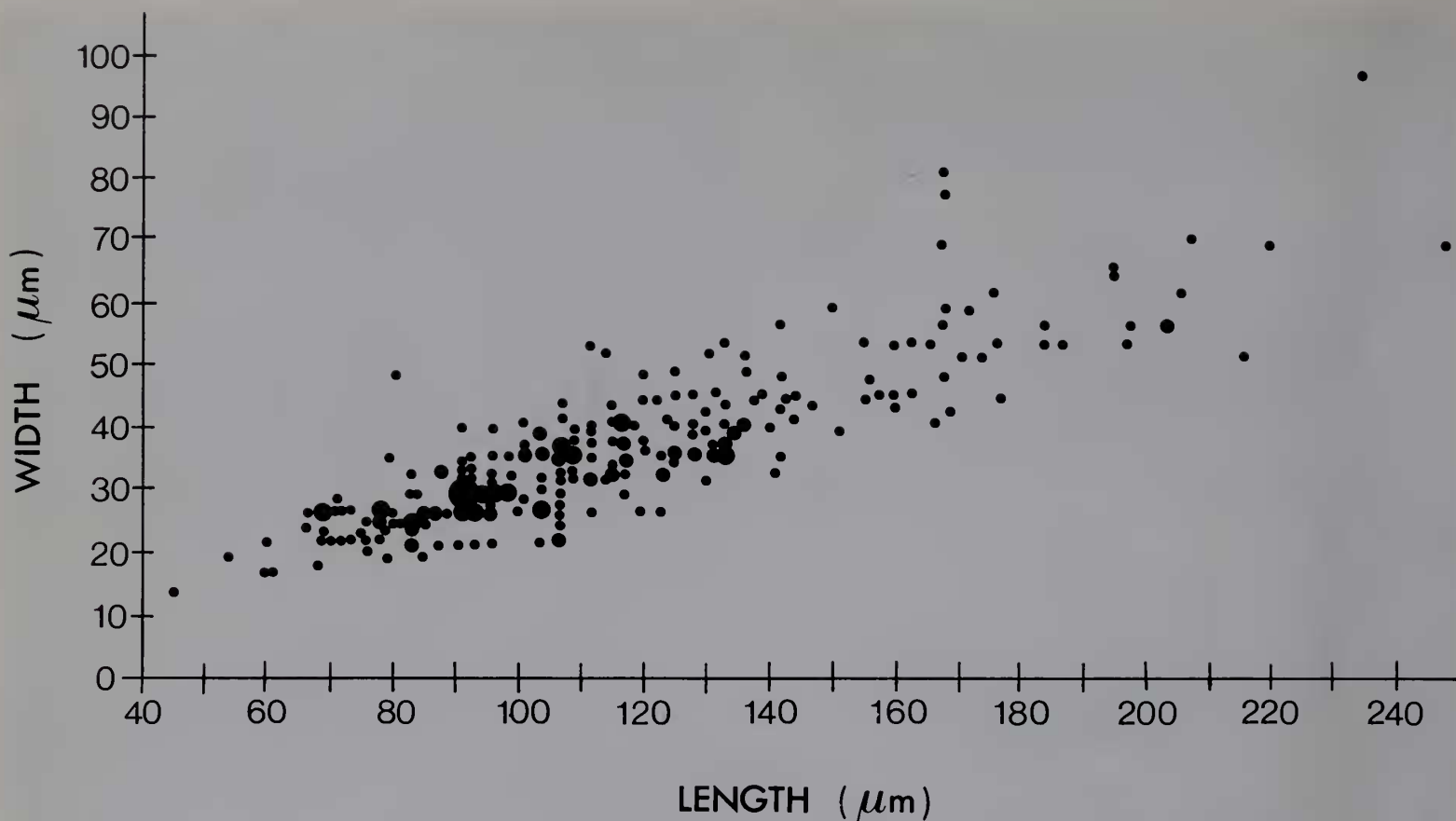


Fig. 4 *Tinogullmia riemanni* sp. nov. Plot of test length (including terminal tubes) against width for 250 specimens from BIOTRANS samples.

51502) and July (Stn 51615) at the Porcupine Seabight site. Phytodetritus was present during July but not during April. In the April sediment samples *T. riemanni* occurred only very occasionally. When sorting sediment subsamples from the July cores, aggregates of phytodetritus were separated from the sieve residues and examined separately for living inhabitants. More than three quarters (78%) of the 171 specimens of *T. riemanni* originating from Stn 51615 were found in the sediment assemblage, where the new species made up 3.13% of the total foraminiferal population and was ranked seventh in abundance (Gooday & Lamshead 1989). Thus, it was significantly more abundant in sediments overlain by phytodetritus than in sediments collected in the same area, earlier in the year, before the deposition of phytodetritus. Only 22% of *T. riemanni* specimens occurred within the phytodetritus. Included among these were a few specimens found within empty copepod moults which probably originated from the detrital aggregates (Fig. 8f, g). It is not clear why the proportion of detritus inhabiting specimens should be lower at this bathyal site than in the much deeper BIOTRANS samples. However, one possible explanation is that specimens were washed out from the detritus into the sediment during the storage and sieving of samples (Gooday and Lamshead 1989).

Recently (September 1989), *T. riemanni* has been discovered in phytodetrital samples collected from the Porcupine Abyssal Plain (48° 50'N, 16° 30'W, 4810m), midway between the Porcupine Seabight and the BIOTRANS area.

Gooday (1986b) has reviewed the sparse literature on deep-sea allogromiins. The abundance of these foraminifera in a box core recovered from 7298m in the Aleutian Trench (Jumars & Hessler 1976) may reflect the high food supply to this region. A connection with organic material is also suggested by Wolff's (1979a, 1979b) report of three

allogromiins attached to the inner wall of a *Thalassia* rhizome from 2288m in the northwest Atlantic off Georgia. Such a relationship would be consistent with observations on the habitat preferences of shallower water allogromiins. Most information is available from the Gullmar Fjord and Skagerak where a diversity of such foraminifera thrive on the uppermost detrital layers of soft, muddy sediments at depths of a few tens to a few hundreds of metres (Nyholm 1953, 1954, 1955, 1957, Nyholm & Gertz 1973). An unnamed allogromiin is the second most abundant foraminiferal species living in an intertidal mudflat (presumably rich in organic material) near the mouth of the river Tamar, southwest England (Ellison 1984).

ACKNOWLEDGEMENTS. I thank Prof. H. Thiel for inviting me to participate in *Meteor* Cruise 3, Dr M. V. Angel, Mr M. H. Thurston and Dr J. Whittaker for critically reading the manuscript, and Mr M. Conquer for his careful photographic printing. This is BIOTRANS publication no. 18.

REFERENCES

- Arnold, Z. M. 1954. Variation and isomorphism in *Allogromia laticollaris*: a clue to foraminiferal evolution. *Contributions from the Cushman Foundation for Foraminiferal Research* 5: 78–87.
- Barnett, P. R. O., Watson, J. & Connelly, D. 1984. A multiple corer for taking virtually undisturbed samples from shelf, bathyal and abyssal sediments. *Oceanologica Acta* 7: 399–408.
- Billett, D. S. M., Lampitt, R. S., Rice, A. L. & Mantoura, R. F. C. 1983. Seasonal sedimentation of phytodetritus to the deep-sea benthos. *Nature* 302: 520–522.
- Ellison, R. L. 1984. Foraminifera and meiofauna on an intertidal mudflat, Cornwall, England: Populations; respiration and secondary production; and energy budget. *Hydrobiologica* 109: 131–148.

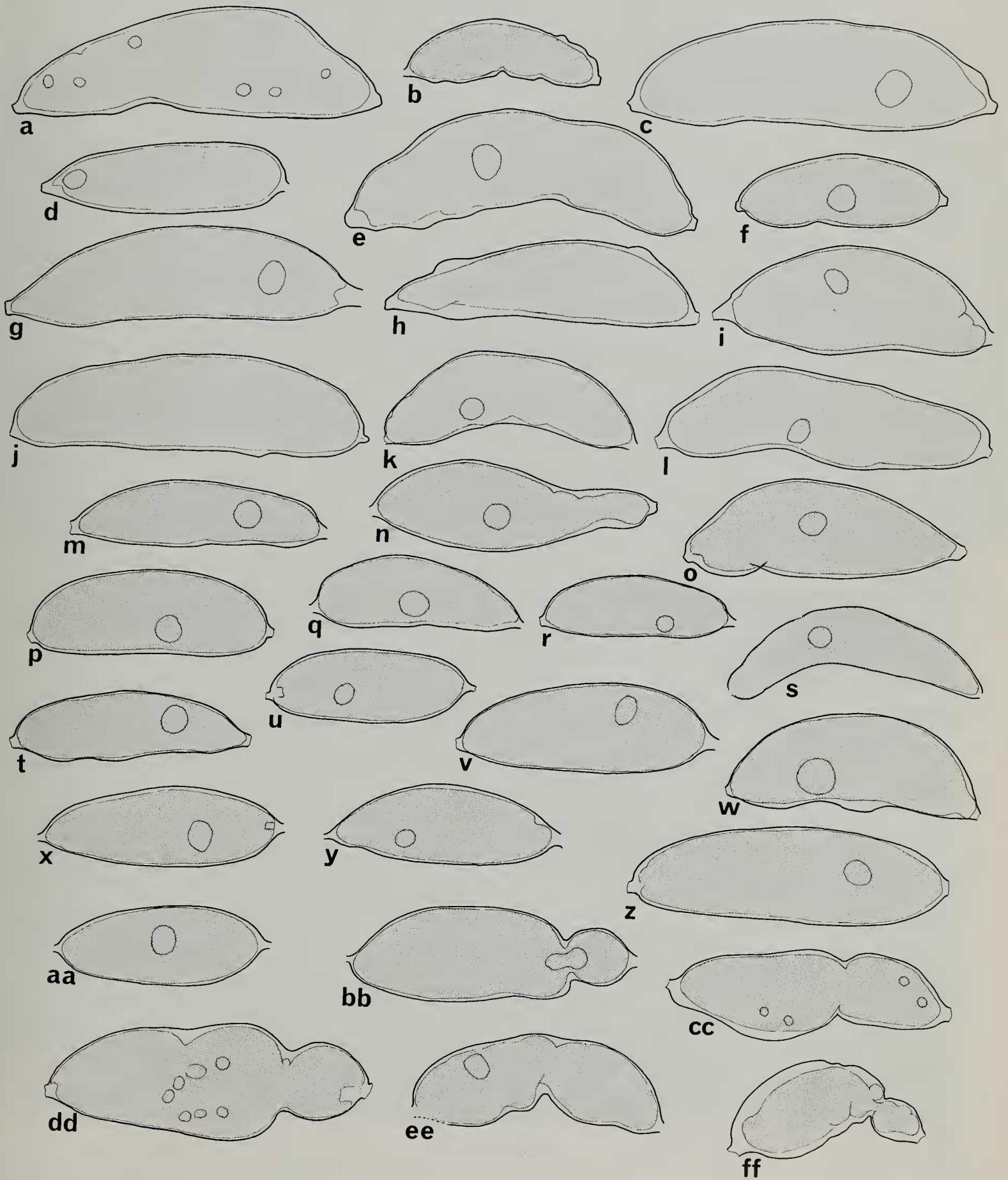


Fig. 5 *Tinogullmia riemanni* sp. nov. Specimens of form A from Stn 51615, Porcupine Seabight: samples 51615/1A (a, c, d, l, m, aa, cc); 51615/1B (e, g, k, n, o, p, r, v, w); 51615/5B (h, i, u, y); 51615/5C (b, j, s, x, z, ff); 51615/5D (f, q, t, bb, dd, ee). Scale bar = 100µm.

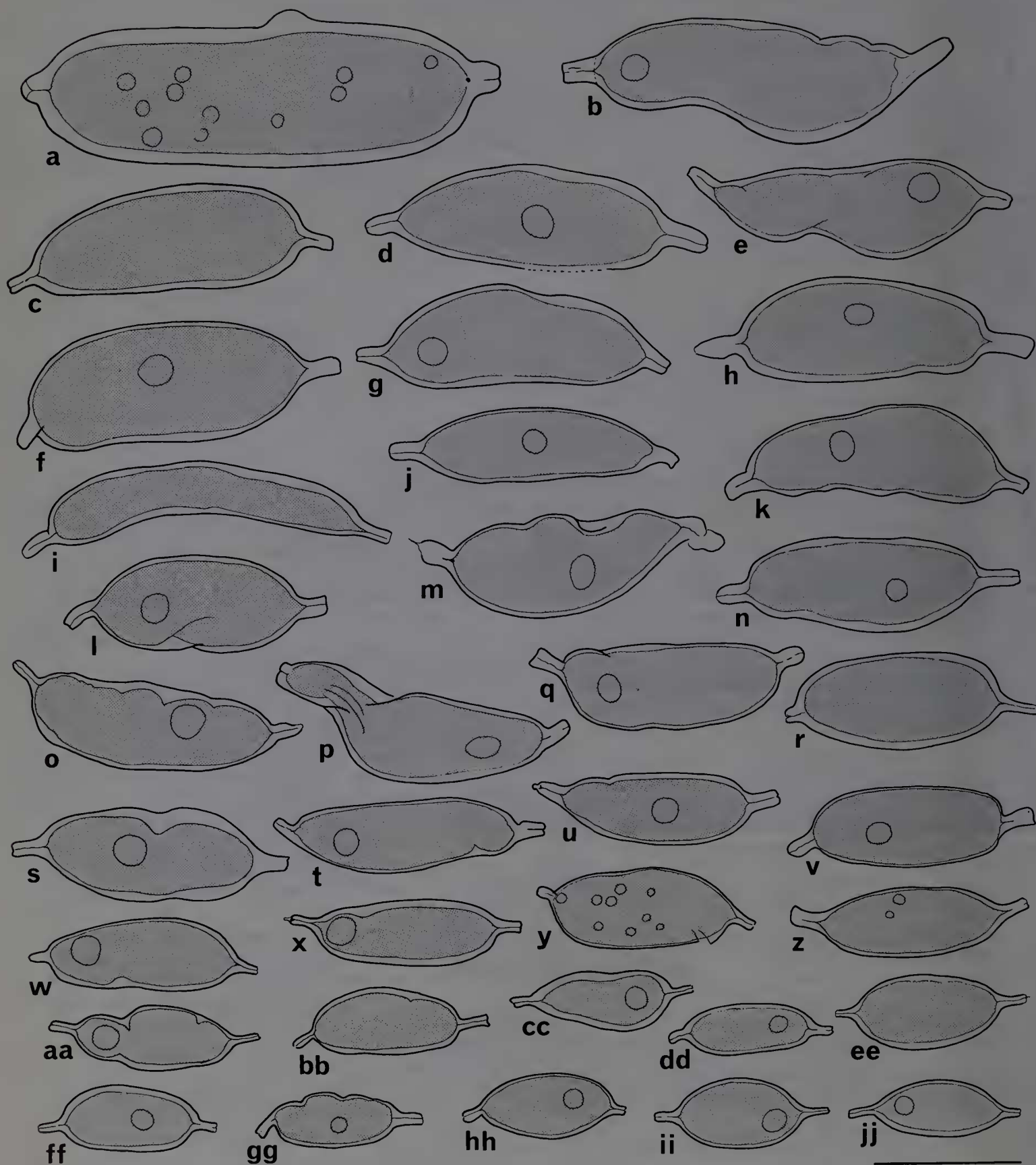


Fig. 6 *Tinogullmia riemanni* sp. nov. Specimens of form B from Stn 51615, Porcupine Seabight: samples 51615/1A (b, t, gg); 51615/1B (e-g, j, l, s, w, x, z, aa, jj); 51615/5B (i); 51615/5C (a, c); 51615/5D (d, h, n, p, q, u, v, bb-ff, hh, ii); 51615/6A (r); 51615/6B (k, m, o, y).

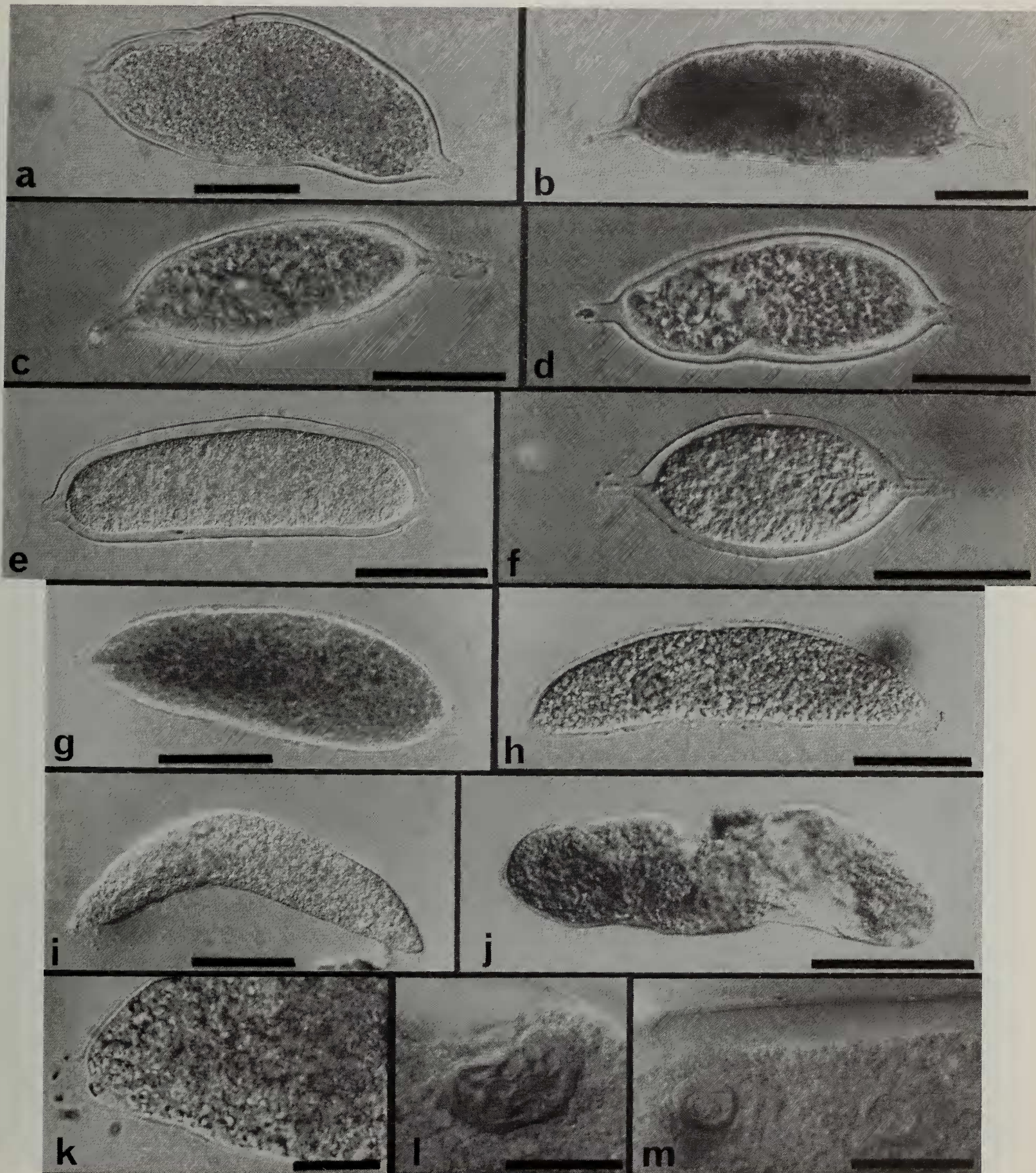


Fig. 7 *Tinogullmia riemanni* sp. nov. Specimens from Stn 51615, Porcupine Seabight. Form B, sample 51615/1B (a, c, d); form B, sample 51615/5D (b, f); form B, sample 51615/5C (e); form A, sample 51615/1B (g); form A, sample 51615/1A (h); form A, sample 51615/5C (i); form A, sample 51615/4D (j); form A, sample 51615/4D, end of test with apertural tube (k); form A, sample 51615/4D, nucleus (l); form B, 51615/5C, nuclei of multinucleate specimen illustrated in e (m). Scales: a-d, f-i = 50µm; e, j, = 100µm; k, m = 25µm; l = 10µm. a, b, e-m taken using Nomarski interference contrast, others using phase contrast.

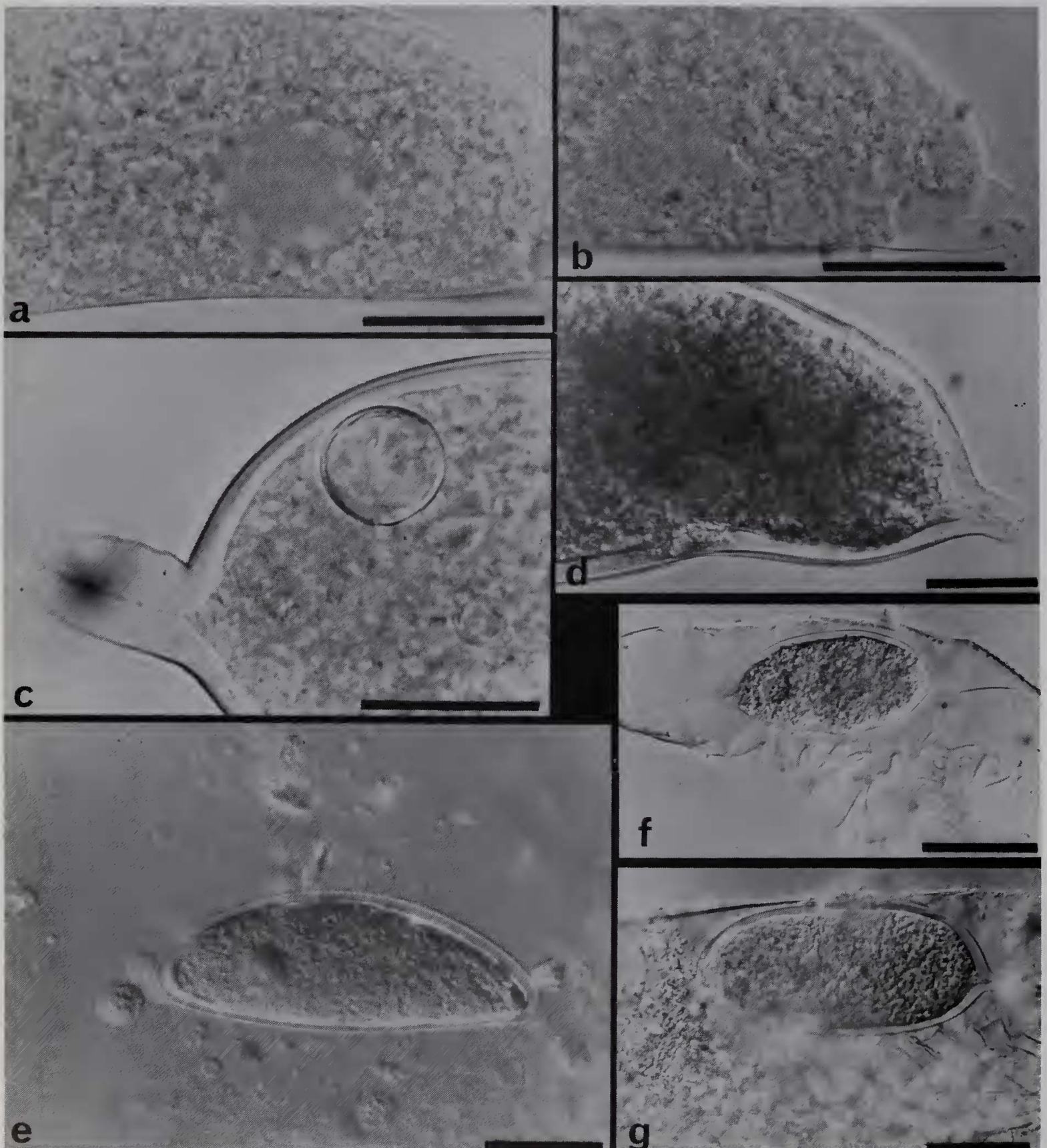


Fig. 8 *Tinogullmia riemanni* sp. nov. Specimens from BIOTRANS area (a, b, e) and Stn 51615, Porcupine Seabight (c, d, f, g). Stn 200, detail of nucleus of specimen illustrated in Fig. 3b (a); detail of apertural tube and endosolon of same specimen (b); sample 51615/1A, apertural tube and transparent, vacuole-like structure (c); sample 51615/1B, end of specimen illustrated in Fig. 7a showing apertural tube (d); Stn 200, specimen embedded in phytodetritus; the spherical structures are 'minipellets' produced by phaeodarian radiolarians (e); sample 51615/5D, specimens inside empty copepod moults (f, g). Scales: a-d = 25 μ m; e-g = 50 μ m. All photographs were taken using Nomarski interference contrast.

- Goldstein, S. T.** 1988. On the life cycle of *Saccamina alba* Hedley, 1962. *Journal of Foraminiferal Research* **18**: 311–325.
- Gooday, A. J.** 1986a. Soft-shelled Foraminifera in meiofaunal samples from the bathyal northeast Atlantic. *Sarsia* **71**: 275–287.
- 1986b. Meiofaunal foraminiferans from the bathyal Porcupine Seabight (northeast Atlantic): size structure, standing stock, taxonomic composition, species diversity and vertical distribution in the sediment. *Deep-sea Research* **33**: 1345–1373.
- 1988a. A response by benthic Foraminifera to the deposition of phytodetritus in the deep sea. *Nature* **332**: 70–73.
- 1988b. Phylum Sarcocystigophora. In Higgins, R. & Thiel, H. (Editors) *An Introduction to the Study of Meiofauna*. Washington D.C., London (Smithsonian Institution Press): 243–257.
- & **Lambhead, P. J. D.** 1989. The influence of seasonally deposited phytodetritus on benthic foraminiferal populations in the bathyal northeast Atlantic: the species response. *Marine Ecology-Progress Series* **58**: 63–67.
- Grell, K. G.** 1988. The life-cycle of the monothalamous foraminifer *Heterotheca lobata* n. gen. n. sp. *Journal of Foraminiferal Research* **18**: 54–74.
- Hedley, R. H., Parry, D. M. & Wakefield, J. St. J.** 1968. Reproduction in *Boderia turneri* (Foraminifera). *Journal of Natural History* **2**: 147–151.
- Jumars, P. A. & Hessler, R. R.** 1976. Hadal community structure: implications from the Aleutian Trench. *Journal of Marine Research* **34**: 547–560.
- Knight, R.** 1986. Apertural characteristics of certain unilocular foraminifera; methods of study, nomenclature and taxonomic significance. *Journal of Micropalaeontology* **5**: 37–47.
- Lampitt, R. S.** 1985. Evidence for the seasonal deposition of detritus to the deep-sea floor and its subsequent resuspension. *Deep-Sea Research* **32**: 885–897.
- Lochte, K. & Turley, C. M.** 1988. Bacteria and cyanobacteria associated with phytodetritus in the deep-sea. *Nature* **333**: 67–69.
- Loeblich, A. R. Jr. & Tappan, H.** 1961. Suprageneric classification of the Rhizopodea. *Journal of Paleontology* **35**: 245–330.
- & — 1984. Suprageneric classification of the Foraminiferida (Protozoa). *Micropalaeontology* **30**: 1–70.
- & — 1988. *Foraminiferal Genera and their Classification*. New York (Van Nostrand Reinhold Company). 970pp, 847pls, 2 vols.
- Nyholm, K. -G.** 1953. Studies on Recent Allogromiidae (2): *Nemogullmia longivariabilis* n.g., n.sp., from the Gullmar Fjord. *Contributions from the Cushman Foundation for Foraminiferal Research* **4**: 105–106, pl. 18.
- 1954. Studies on Recent Allogromiidae (3): *Tinogullmia hyalina* n. gen., n. sp., from the Gullmar Fjord, Sweden. *Contributions from the Cushman Foundation for Foraminiferal Research* **5**: 36, pl. 7.
- 1955. Studies on Recent Allogromiidae (4): *Phainogullmia aurata* n. gen. n. sp. *Zoologiska Bidrag från Uppsala* **30**: 465–474, pls 1–5.
- 1957. Orientation and binding power of Recent monothalamous Foraminifera in soft sediments. *Micropalaeontology* **3**: 76–77.
- 1974. New monothalamous foraminifera. *Zoon* **2**: 117–122.
- & **Gertz, I.** 1973. To the biology of the monothalamous foraminifer *Allogromia marina* n. sp. *Zoon* **1**: 89–93.
- Rhumbler, L.** 1904. Systematische Zusammenstellung der recenten Reticulosa. *Archiv für Protistenkunde* **3**: 181–294.
- Rice, A. L., Billett, D. S. M., Fry, J., John, A. W. G., Lampitt, R. S., Mantoura, R. F. C. & Morris, R. J.** 1986. Seasonal deposition of phytodetritus to the deep-sea floor. *Proceedings of the Royal Society Edinburgh* **88B**: 265–279.
- Schwab, D.** 1977. Light and electron microscopic investigations on the monothalamous foraminifer *Boderia albicollaris* n. sp. *Journal of Foraminiferal Research* **7**: 189–195, pls 1–3.
- Siddall, J. D.** 1880. On *Shepherdella*, an undescribed type of marine Rhizopoda; with new observations on *Lieberkuhnia*. *Quarterly Journal of Microscopical Science* **20**: 130–145.
- Thiel, H., Pfannkuche, O., Schriever, G., Lochte, K., Gooday, A. J., Hemleben, Ch., Mantoura, R. F. C., Turley, C. M., Patching, J. W., Riemann, F.** 1990. Phytodetritus on the deep-sea floor in a central oceanic region of the northeast Atlantic. *Biological Oceanography* **6**: 203–239.
- Wolff, T.** 1979a. Macrofaunal utilization of plant remains in the deep-sea. *Sarsia* **64**: 117–136.
- 1979b. Animals associated with seagrass in the deep-sea. In Phillips, R. C. & McRoy, R. C. (Editors) *A Handbook of Seagrass Biology: an Ecosystem Perspective*. New York (Garland Publishing Company): 199–224.